

Experimental Investigation on Self Compacting Concrete by Partial Replacement of Fine Aggregate with Quarry Dust and Cement with Fly Ash

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ABSTRACT: Self-compacting concrete (SCC) is a flowing concrete that spreads through congested reinforcement, fills every corner of the formwork, and is compacted under its self weight. SCC requires excellent filling ability, good passing ability, and adequate segregation resistance. It can flow with ease in congested reinforcement at beam-column junctions and the use of SCC shortens the construction period since it allows faster placement and less finishing time, simultaneously ensuring proper filling of restricted areas with minimum or no compacting leading to improved productivity.

The present study focuses on utilization of quarry dust and fly ash in SCC as a partial replacement of fine aggregate and cement respectively. In this project, work done on experimental study on fresh and hardened properties such as flow ability, passing ability, compressive, tensile and flexural strength of M40 grade of SCC. In this investigation SCC was made with partially replacing fine aggregate with quarry dust and cement with fly ash. Six mixes with different percentages of quarry dust (0%, 10%, 20%, 30%, 40% and 50%) as partial replacement for sand 30% of fly ash as partial replacement for cement is considered.

For each mix workability and hardened tests are carried out respectively. The test results for hardened properties are carried out at 3, 7, 28 days respectively. The results obtained regards the possibility for obtaining the SCC using quarry dust and fly ash, and also studied its variation in strength properties for different percentages of quarry dust.

KEYWORDS: self compacting concrete (SCC), quarry dust, flowing ability, passing ability.

I. INTRODUCTION

Concrete that flows and settles due to its own weight without segregation and bleeding is called SCC. It has various advantages over natural vibrated concrete (NVC). This is a special type of concrete specially designed by Japanese researchers in 1980 for congested reinforcements.

In SCC no vibration is required for compaction, as it flows like honey and after placing it has a very smooth surface. SCC and NVC consist of same constituent elements like cement, FA, CA, admixtures in varying proportions and same engineering properties. Application on SCC with variation in mix design i.e. partial replacement of FA or CA has shown its respective effects on strength properties. This paper focuses on investigation of fresh and hardened properties of SCC produced with Q.D.

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II. RELATED WORK

“**Celik, T. and K. Marar (1996)**” Reported the effects of partial replacement of fine aggregate with crushed stone dust (particle size less than 75 microns), it was observed that slump value decreased as the percentage of dust content increased. Also for higher dust contents, the compressive strength, flexural strength, and impact resistance decreased gradually where as absorption increased.

The use of quarry sand is generally limited due to the high cement paste volume needed to obtain an adequate workability. The amount of additional paste content depends on texture, shape, grading, and dust content of the sand. The increase of water demand of concrete mixtures produced by the adverse effects of texture and shape of quarry sand can be minimized by using a HRWR.

Murugesan et al (2006) concluded that the compressive strength and flow ability can be enhanced in quarry dust replaced concrete with the use of super plasticizers. The quarry dust was mixed in various proportions, replacing sand by 30-90% in conventional concrete. It was found that, 60% replacement of sand by quarry dust without plasticizer and 70% - 80% replacement with plasticizer produced the same compressive strength as that of conventional concrete. It is recommended that, to overcome the problem of poor flow ability with the large proportions of quarry dust in fine aggregate, super plasticizer at the dosage of 0.4% by weight of cement can be used.

Naidu et al (2003a) Naidu et al (2003a) have conducted an experimental study to examine the behavior of partial replacement of river sand with quarry waste in the compressive strength and pull-out force of concrete. Four types of concrete, with two water-binder ratios of 0.40 and 0.45 were undertaken in this study. Replacement proportion of 20% natural sand with quarry waste was practiced in all the concretes except in the controlled concrete mix.

All concretes were cured by dry air in the curing room at 20°C, and their compressive strength and pull-out force were measured on the 7th, 14th, 28th and 56th day. Test results indicate that concrete incorporating quarry dust and without the inclusion any mineral admixture exhibited a lower compressive strength but a higher pull-out force than the controlled concrete at all ages.

“**Ilangoan et al (2008)**” reported that the strength of quarry dust concrete increases by 10-12 % with reference to the similar mix of traditional concrete. He further, concluded that under sulphate and acid action, the durability of quarry rock dust concrete is higher to that of traditional concrete. This was concluded from the test results of Permeability test which clearly confirmed that the permeability of quarry rock dust concrete is lesser than the conventional concrete. The water absorption of quarry rock dust concrete was found to be slightly higher than concrete using natural fine aggregate.

He concluded that when compared to conventional concrete the workability value of Quarry rock dust concrete decreases. Quarry rock dust concrete experiences better sulphate and acid resistance and permeability than that to concrete made with natural aggregates. However, the water absorption of concrete made of Quarry Rock Dust concrete more than concrete made with natural aggregate.

III. EXPERIMENTAL INVESTIGATION

Materials used:

Cement:

Ordinary Portland cement (OPC) of grade 43 conforming to IS 8112-1989 is used. Various lab tests conforming to 4031-1996(part-1) carried out.

Fly Ash:

Fly ash (class-F) obtained from NTPC Visakhapatnam is used. Fly ash is not processed and used as received.

Chemical Admixture:

Poly carboxylic ether based super plasticizer with viscosity modified admixture named master Glenium sky 8630/8632.

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Table.1 physical Properties of Cement and Fly Ash.

Sl no.	Physical Properties	Observed value for cement	Observed values for fly ash
1	Specific Gravity	3.14	2.2
2	Initial Setting (minutes)	38 min	45 min
3	Final Setting (minutes)	600 min	280 min
4	Consistency (%)	30%	35%
6	Fineness	9.25%	31.5%

Table.2 Chemical Properties of superplasticizer

Aspect	Light brown liquid
Relative density	1.08 ± 0.01 at 25°C
pH	≥ 6 at 25°C
Chloride ion content	< 0.2%

missing pixels. This technique uses an approach which combine structure propagation with texture synthesis and hence produced very good results. In [3], the authors decompose the image into sum of two functions and then reconstruct each function separately with structure and texture filling-in algorithms. Morphological technique is used to extract text from the images presented in [4]. In [5], the inpainting technique is combined with the techniques of finding text in images and a simple algorithm that links them. The technique is insensitive to noise, skew and text orientation. The authors in [6] have applied the CCL (connected component labelling) to detect the text and fast marching algorithm is used for Inpainting.

The work in this paper is divided in two stages. 1) Text- Detection 2) Inpainting. Text detection is done by applying morphological open-close and close-open filters and combines the images. Thereafter, gradient is applied to detect the edges followed by thresholding and morphological dilation, erosion operation. Then, connected component labelling is performed to label each object separately. Finally, the set of selection criteria is applied to filter out non text regions. After text detection, text inpainting is accomplished by using exemplar based Inpainting algorithm.

Paper is organized as follows. Section II describes automatic text detection using morphological operations, connected component analysis and set of selection or rejection criteria. The flow diagram represents the step of the algorithm. After detection of text, how text region is filled using an Inpainting technique that is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

Aggregates:

Coarse aggregate: Locally available crushed stone of 20mm graded size has been used as coarse aggregate.

Fine aggregate: River sand from river bed having following characteristics.

Table.3 characteristics of CA.

Test property	Natural coarse aggregate
Specific gravity	2.87
Water absorption	0.25%
Aggregate crushing(%)	24
Aggregate impact(%)	29

Table.4 Characteristics of FA

Specific gravity	2.63
fineness	2.60
Water absorption	2.56

Quarry dust: Quarry dust is used as an inert powder. It has been obtained from stone crusher Zone-II as per IS: 383-1970.

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Table.5 physical properties for the quarry dust

Specific gravity	2.756
Water absorption	0.85%

Mix proportioning:

In this study SCC mixes of M40 grade is produced as per code IS 10262-2009 with six different weight percentages of Q.D as replacement of FA to study the effect on flow ability, compressive and tensile strength. The use of fly ash in concrete is taken 30%, water binder ratio is taken 0.4. The detailed proportions of various ingredients of SCC below.

Table.6. Mix proportion M40

Mix no	Cement	%fly ash	% QD	QD (kg)	W/B ratio	CA (kgs)	FA (kgs)	Water(litr)	Ad-mix%
1.	270	30	0	0	0.36	1017.2	925.3	168	2.2
2.	270	30	10	98.36	0.36	1017.2	832.8	166.3	2.2
3.	270	30	20	196.82	0.36	1017.	740.2	164.7	2.2
4.	270	30	30	295.27	0.36	1017.2	605.5	163.12	2.2
5.	270	30	40	393.7	0.36	1017.2	555.26	161.5	2.2
6.	270	30	50	492.3	0.36	1017.2	461.7	160.4	2.2

Testing methods Of SCC:

Sl.	Method	Property
1	T _{50cm} Slump Flow	Filling ability
2	V-Funnel	Filling ability
3	L-Box Passing	Passing ability
4.	Compressive strength	Compressive strength
5.	Split tensile strength	Tensile strength
6.	Flexural strength	Flexural strength

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IV. RESULTS AND DISCUSSIONS

Fresh properties:

The following are the results obtained in various laboratory tests carried out in this study.

Table.7 workability results

Mix no	% QD	slump flow test (t in sec)		L value (h ₂ /h ₁)	v (t in sec)
		500mm	700 mm		
1	0	2	4	0.8	10.8
2	10	2.2	6	0.8	10.6
3	20	3	8.6	0.8	10.5
4	30	1.6	7.8	0.96	8
5	40	2.4	11.5	0.8	9
6	50	2	9	0.86	10

T500 is the time for which the concrete reaches the diameter of 500mm and was measured during slump flow test. This value for all the mixes with QD is between 2-3 sec and with a minimum flow of 650mm as recommended for engineering applications.

The filling and flowing measured using v-funnel ranges from 2-5 sec, passing test using L-box gives less than 1 which are acceptable.



Fig.4. Graph representing flow ability results

The graph is plot between time in sec and %QD indicating the flow ability. It can be seen that as %QD increases the flow time increases upto 30% and then decreases..

A graph is plot between % QD on X-axis, blocking ratio in Y-axis, which indicates as QD increases blocking ratio initially remains constant than increases at 30% and then decreases but are within limits.

HARDENED PROPERTIES: The compressive, tensile and flexural strengths of the all concrete mixes determined at 3, 7, 28 days are given below.

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Strength Results

Table.9. Compressive Strength results

Mix no	% QD	Compressive strength(mpa)		
		3days	7days	28days
1	0	13.71	20.57	42.86
2	10	14.63	21.51	43.02
3	20	15.71	22.7	43.65
4	30	17.32	25.28	46.82
5	40	15.20	22.79	44.68
6	50	14.46	21.47	43.83

Table.10. split tensile Strength results

Mix no	% QD	Split tensile strength(mpa)		
		3days	7days	28days
1	0	1	1.5	3.14
2	10	1.09	1.62	3.22
3	20	1.19	1.71	3.29
4	30	1.25	1.85	3.43
5	40	1.27	1.87	3.71
6	50	1.29	1.88	3.62

Table.11 Flexural Strength results

Mix no	% RCA	Flexural strength(mpa)		
		3days	7days	28days
1	0	2.6	4.58	5.7
2	10	2.9	4.7	5.85
3	20	3.21	4.9	5.90
4	30	3.4	5.28	6.20
5	40	3.2	5.10	6.10
6	50	3.1	4.92	5.9

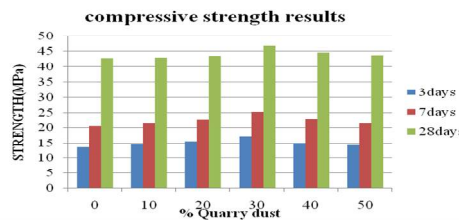


Fig. 6. %QD (vs.) Compressive strength

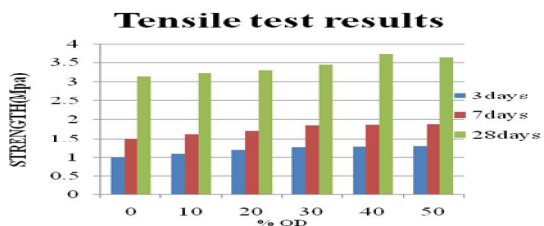


Fig.7 %QD (vs.) Tensile Strength

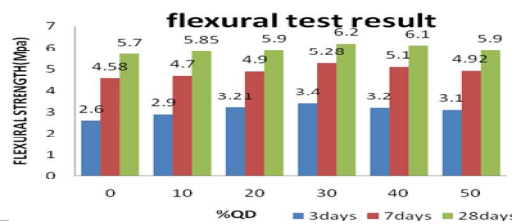


Fig.8 %QD (vs.) Flexural Strength

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The graphs plotted between percent QD on X-axis and compressive strength, tensile and flexural strength on Y-axis shows the variation of strengths with increase in % QD at 3,7,28 days respectively.

From the results obtained and the graph plotted it can be seen that as the % QD increases, increase in strength is observed upto 30% replacement, upon which there is a consistent decrease in strength with % increase in QD.

V.CONCLUSIONS

From the present investigation and limited observations reported, on the effect of partial replacement of quarry dust with fine aggregate in SCC mixes, following conclusions can be drawn:

- The slump flow varied between the ranges of 650-725mm. At 30% partial replacement of fine aggregate by quarry dust minimum flow time of 1.6sec and 8 sec was observed in slump flow and v-funnel test respectively.
- However all the three workability tests were within the acceptable limits of EFNARC.
- In Compressive strength test with increase in percentage partial replacement of fine aggregate with quarry dust at 0%-30%, observed the increase in compressive strength by 8%. Further with increase in percentage partial replacement of fine aggregate with QD at 30 to 40% and 40 to 50% decreased the strength gradually by 4% and 2% respectively.
- In case of split tensile test with increase in percentage partial replacement of FA with QD at 0% to 40%, increased the strength by 15%. Further with increase in partial replacement from 40-50% has decreased the strength by 2%.
- In flexural strength test increase in strength by 8% is observed with increase in partial replacement of FA with QD at 0% to 30%. Further with increase in partial replacement from 30% to 40% and 40 to 50% has decreased the strength by 2% and 3% respectively.
- From all the results and points discussed above it can be concluded that the fly ash and quarry dust replacement showed the desirable results that can suggest the usage of the quarry dust as replacement.
- From overall view it can also be concluded that the partial replacement of quarry dust beyond 30%, there will be decrease in the compressive strength and flexural strength values of cube and prism specimens where as in case of split tensile test decrease in strength is observed with partial replacement of FA by QD beyond 40%.

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